Reflections In 127 Electrostatic Electron Selector At 2 keV

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Elektronların seçici yüzeyinden yansımasının odaklama karakteristiği üzerindeki etkisini incelemek üzere 2 keV elektronlar için aralığı 0,215 cm ortalama yarıçapı 2,105 cm olan bir 127° 17'lık elektrostatik hız seçicisi yapılmıştır. Yapılan deneyler neticesinde görüldüki bu enerji dahilinde yüzeylerden yansımalar istenilen enerjideki ana geçiş çizgisinin odaklanmasına hissedilir derecede tesir etmemektedir. Dolayısı ile (1 - 4 eV) elektron enerjilerinde olduğu gibi seçici elektronla donatılmış koruyucu gridlere bu elektron enerjilerinde ihtiyaç yoktur.

A 127° 17' electrostatic velocity selector has been constructed with a small gap of 0.215 cm and 2.105 cm mean radius for 2 keV electrons to study the effect of electron reflections from the selector walls on the focussing characteristics. It has been observed that reflections from the walls at this energy range do not appreciably affect the focussing of the central trajectories of desired energy. Therefore one does not need deflecting grids with the selector electrodes at these energies as one does at lower (1 - 4 eV) electron energies.

INTRODUCTION

Recently 127° 17' electrostatic electron velocity selectors have been widely studied and used as monochromators and spectrometers where monoenergetic electron beams are required and where an electron energy spectrum needs to be analysed.

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This selector was first constructed by Hughes and McMillan(1) who used a special filament arrangement for velocity analysis of 99 eV electrons. For low energy electrons, 0.1-4 eV, an analyser was constructed by Marmet and Kerwin(2) who used deflecting grids with the electrodes to suppress the electron reflection effects from the walls of the electrodes. Electrostatic selectors have also been used at higher electron energies. For instance John Backus(3) used to analyse 5 keV β - rays.

We study here the effect of electron reflections from the walls on the focussing of the central trajectories for 2 keV electrons. We have constructed a selector with a small gap of 0.215 cm and a mean radius of 2.105 cm for this purpose. It is observed that in this energy range the reflections do not appreciably deteriorate the focussing. Space charge effects have been avoided by controlling input currents to the entrance of the selector.

APPARATUS

A schematic diagram of the apparatus used is shown in Figure 1. Electrons emitted from a tungsten filament heated by a 10 V, 3.5 A D.C supply are accelerated to 2 keV by a symmetrical two tube co-axial electrostatic lens. The lens tubes are 2.54 cm diameter polished copper cylinders of lengths 4.00 cm and 2.76 cm width a gap in between of 0.35 cm these tubes are maintained at 200 and 2000 V respectively with respect to ground. This lens supplies a converging beam of $10^{-7}-10^{-8}$ A to the entrance of the 127° 17′ velocity selector electrodes placed about 3 mm away from the exit of the lens on its axis.

The radii of the selector electrodes are 2 cm and 2.215 cm with a mean trajectory radius of 2.105 cm. These electrodes are made of polished steel and have a width of 1.5 cm each.

The filament, lens and the velocity selector were housed in a nickel plated brass chamber. A vacuum of $\leqslant 10^{-5}$ torr was maintained in this chamber during the experiment with the help of an Edward's oil diffusion pump E04 suitably backed and fitted with a liquid nitrogen trap.

The inner and outer electrodes of the selector require -200 V and $+200$ V for monochromatised focussing of a 2000 eV beam at the exit slit. The electron energy is given by $V = 2E \log (r_2/r_1)$, where E is the electron beam energy in electron volts, $\Delta V = V(r_2) - V(r_1)$ is the deflec-

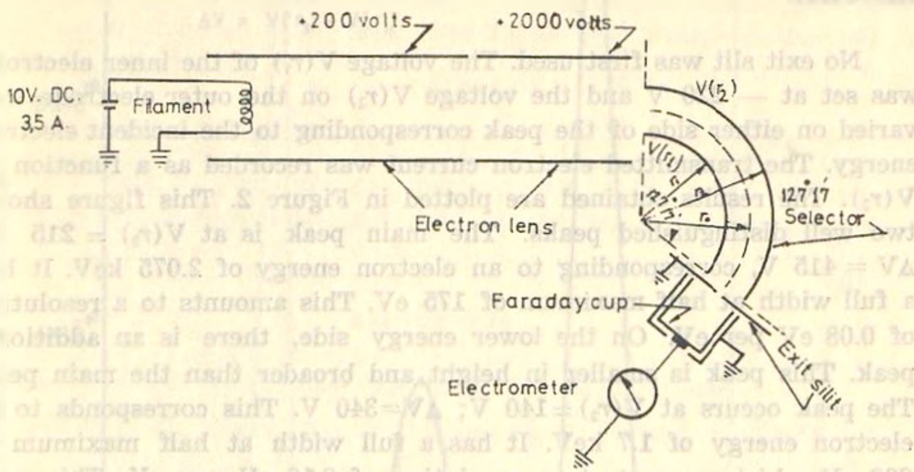

Figure 1. Schematic diagram of 127°17' cylindrical electrostatic electron velocity selector assembly.

tion potential difference in volts across the selector electrodes. The voltages were stable to one part in 10^4.

For out geometry of the velocity selector (entrance aperture $= 1.5 \times 0.215$ cm^2, $r_0 = 2.105$ cm) input currents of the order of 10^{-6} A at 2000 eV energy do not cause any space charge problems(4). We avoid space charge effects by using input currents of the order of $10^{-7} - 10^{-8}$ A.

The electrons are collected by a well shielded Faraday Cup. The electron signal was drawn out of the vacuum chamber via a pin of TL4 Edward's lead through screwed in the base plate of the vacuum chamber. The signal was measured with the help of a high sensitivety electrometer model 1230 A D.C. of General Radio Company, USA.

The filament, lens axis and the entrance aperture of the selector were first aligned optically to achieve best beam alignments. An exit slit of 1 mm width was placed at about 1.5 mm below the exit aperture of the selector The slit was properly grounded. The Faraday Cup was about 1 mm below the exit slit.

RESULTS

No exit slit was first used. The voltage $V(r_1)$ of the inner electrode was set at — 220 V and the voltage $V(r_2)$ on the outer electrode was varied on either side of the peak corresponding to the incident electron energy. The transmitted electron current was recorded as a function of $V(r_2)$. The results obtained are plotted in Figure 2. This figure shows two well distinguished peaks. The main peak is at $V(r_2) = 215$ V; $\Delta V = 415$ V, corresponding to an electron energy of 2.075 keV. It has a full width at half maximum of 175 eV. This amounts to a resolution of 0.08 eV per eV. On the lower energy side, there is an additional peak. This peak is smaller in height and broader than the main peak. The peak occurs at $V(r_2) = 140$ V; $\Delta V = 340$ V. This corresponds to an electron energy of 1.7 keV. It has a full width at half maximum of 260 eV which amounts to a resolution of 0.16 eV per eV. This peak is due to the reflected trajectories from the walls of the electrodes. The selector can focus only those electron trajectories which have an entrance angle $\alpha \leqslant \alpha_{max}$ (4). The smaller peak is due to those electrons which enter the selector with $\alpha > \alpha_{max}$.

The reflected trajectories, however, can be removed by introducing a suitable exit slit. Figure 3 shows the results with a grounded exit slit of 1 mm width. The current is again recorded as a function of $V(r_2)$. This figure shows a sharp and narrow peak at $V(r_2) = 200$ V; $\Delta V = 400$ V corresponding to an electron energy of 2 keV. It has a full width at half maximum of 100 eV which amounts to a resolution of 0.05 eV per eV.

Theoretical energy resolution for this set up is given by (4) $\Delta S / r_0 = 0.47$ eV per eV, where ΔS is thewidth of the exit slit and r_0 is the mean trajectory radius. In our case, $\Delta S = 1$ mm and $r_0 = 2.105$ cm. The experimental resolution obtained is, therefore, not appreciably affected due to reflections from the walls.

This shows that the electron reflection effets from the walls of the selector electrodes do not adversely affect the resolution at higher energies as they do at lower (1 - 4 eV) energies. And therefore one does not need to use deflecting grids with the selector electrodes at higher electron energies (2 keV and higher) as one does at lower energies. After Marmet and Kerwin (2), it became common to use deflector grids even at higher electron energies; e.g. J. Backus (3) uses deflecting

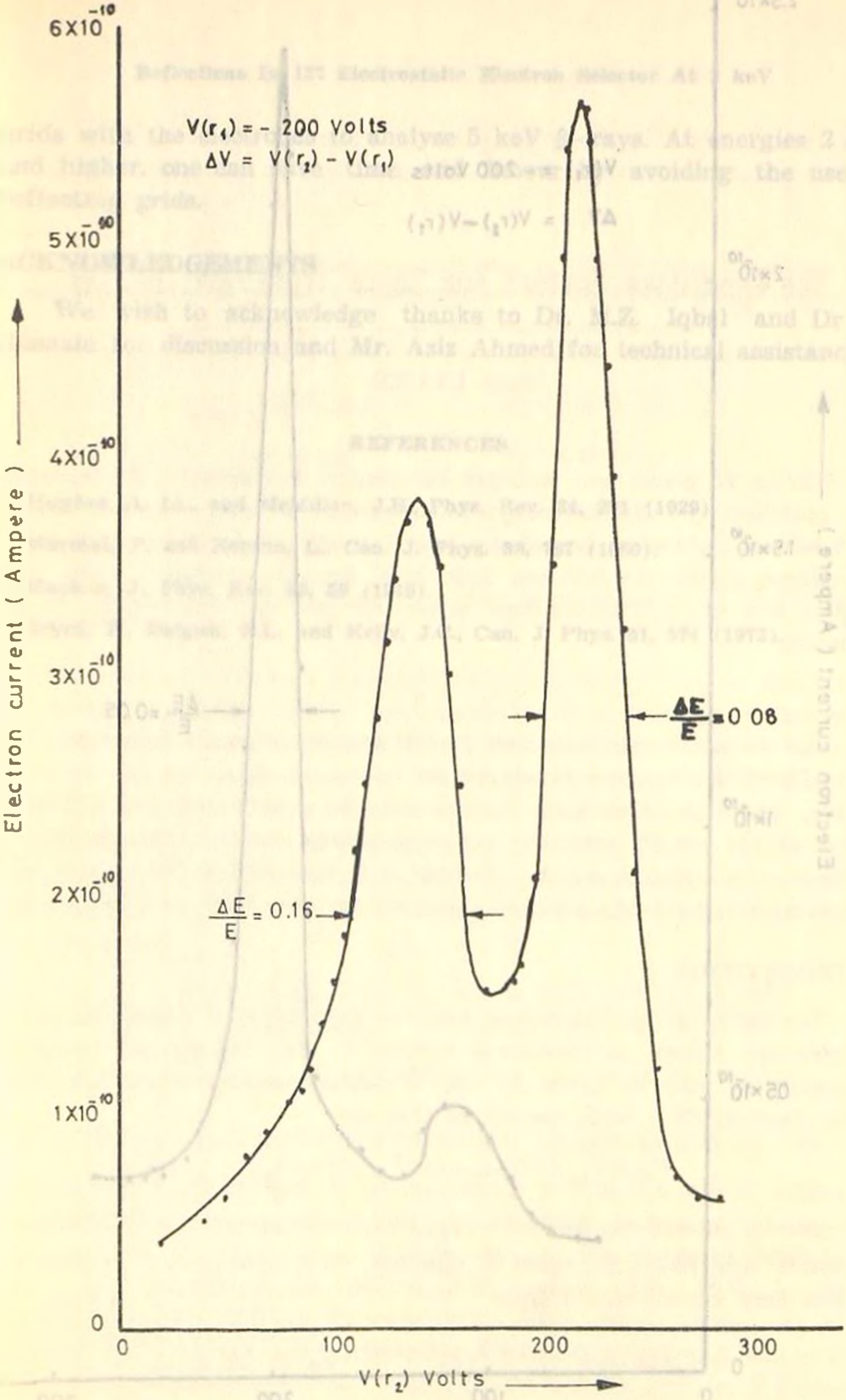

Figure., 2 Electron energy selection without using exit slit

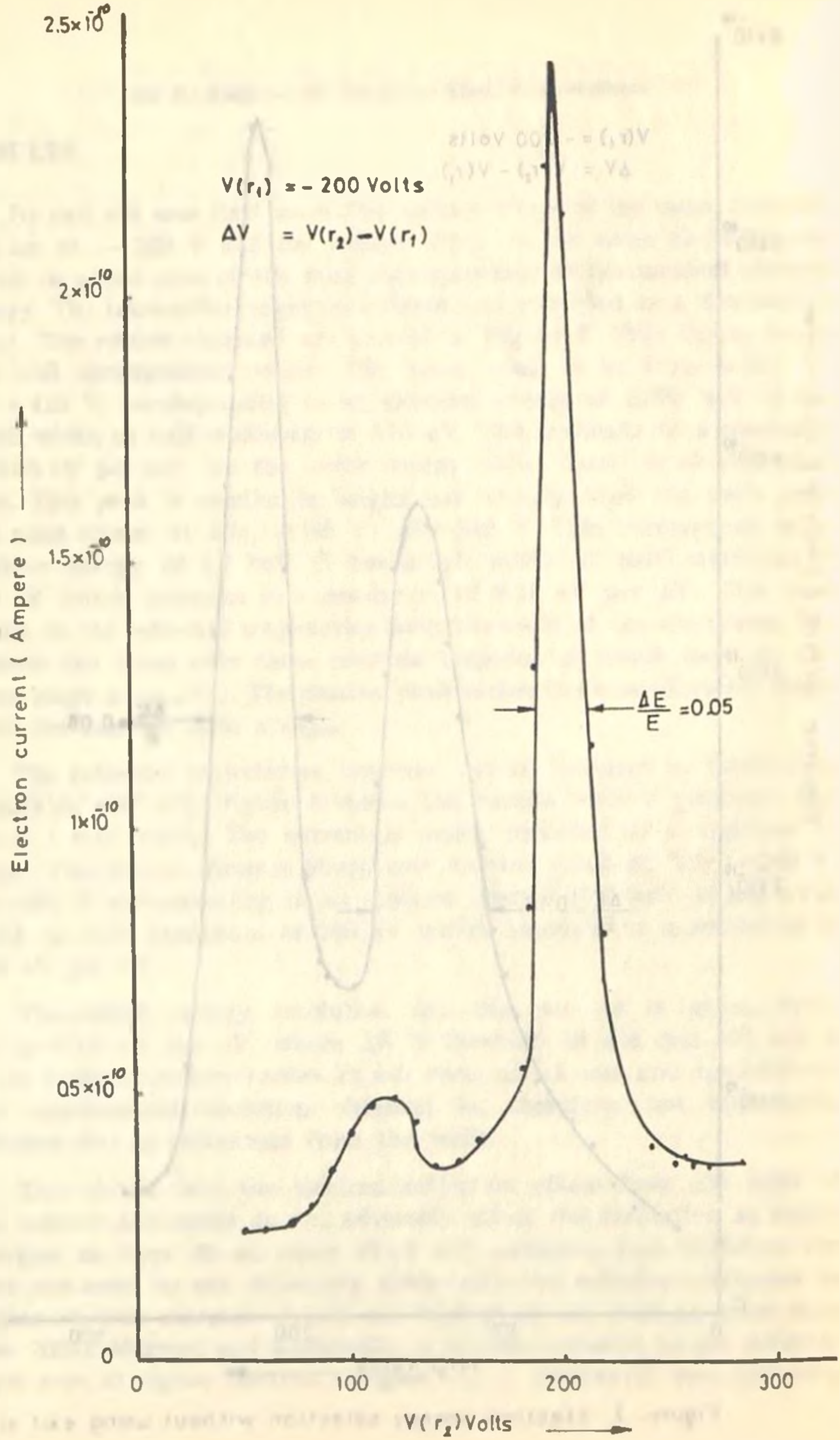

Figure.. 3. Electron energy selection using an exit slit of 1mm grids with the electrodes to analyse 5 keV β - rays. At energies 2 keV and higher, one can save time and labour by avoiding the use of deflecting grids.

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